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STIMULUS CONTROL IN INSTRUMENTAL AUTONOMIC CONDITIONING AND ARO--ETC(U)
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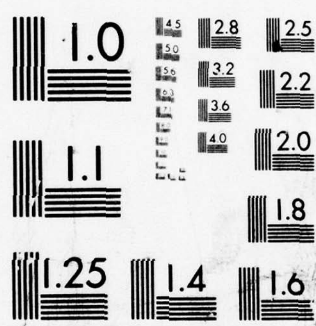

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6 **Stimulus Control in Instrumental Autonomic Conditioning and Arousal**

Annual Report.

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Abstract

Three groups of *Cebus albifrons* monkeys (n = 4 in each) received instrumental conditioning of the skin conductance response (SCR), with periods of Sidman avoidance, response-contingent punishment, and brief times out from these contingencies. One group had previously received this conditioning with visual discriminative stimuli and was now given the same contingencies without the stimuli. A second group served as yoked controls for the first group. The third group received the conditioning without discriminative stimuli from the outset. After 24 sessions (1 hour, 2 per week), the first and second groups were terminated but the third group received 24 additional sessions with the visual stimuli added. The instrumental response was the unelicited SCR. Heart rate was also recorded. It was found that removal of the discriminative stimuli, in the first group, resulted in a significant reduction of the previously established difference in rate of SCR responding during avoidance and punishment (favoring avoidance). This reduction resulted from an increase in response rate during punishment. The first group, nevertheless, still showed significantly more differentiation between avoidance and punishment than their yoked controls. The effect on tonic heart rate of removing the discriminative stimuli was to elevate it somewhat, and to reduce the tendency for the subject to recover from induced heart rate elevations between sessions. Monkeys conditioned from the outset without the lights showed almost no differentiation between avoidance and punishment in their SCR data, until the 4th block of 6 conditioning sessions. Their tonic heart rates also were elevated and tended to be high even at the beginnings of sessions. When the discriminative stimuli were added in the 3rd group, the SCR discrimination

increased and then stabilized but response rates reduced overall. Tonic heart rate lowered and showed a within-session reduction even during conditioning in the last blocks of 6 sessions. It was concluded that the discriminative stimuli play a significant role in the conditioned SCR differentiation but are not absolutely necessary for it, and that chronic autonomic arousal is potentiated by the lack of the discriminative stimuli. The addition of the stimuli following their absence appears to be therapeutic.

Foreword

In conducting the research described in this report, the investigators adhered to the "Guide for Laboratory Animal Facilities and Care," as promulgated by the Committee on the Guide for Laboratory Animal, Resources, National Academy of Sciences-National Research Council.

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Table 1. Number of shocks/minute during avoidance and punishment in monkeys conditioned initially <u>with</u> (n = 4) and initially <u>without</u> (n = 4) discriminatives timuli, averaged in 4 blocks of 6 conditioning sessions. 28

Introduction

Statement of the problem

The research described in this report was aimed at clarifying previously obtained results showing that Cebus albifrons monkeys can learn to differentiate between Sidman avoidance and Punishment schedules of instrumental reinforcement, when the instrumental response is the unelicited plantar skin conductance response (SCR) and that elevation in autonomic arousal accompanies this outcome. The pattern of results previously reported (Kimmel et al, Note 1) suggested that it would be important to examine the role of the visual discriminative stimuli that were used in conjunction with the avoidance and punishment periods, since it was not completely clear that the obtained differentiation was under the control of the discriminative stimuli. Supplemental evaluation of the prior results added somewhat to the impression of stimulus control (Kimmel et al., Note 1), but the need to administer the reinforcement contingencies in the absence of the discriminative stimuli persisted.

In our previous research on this problem we also found that elevated tonic levels of heart rate were generated by the instrumental conditioning procedures employed, but the heart rate measures did not appear to differ in the presence of the avoidance versus the punishment stimulus. In other words, the heart rate change was tonic and not directly under any stimulus control in the way that the SCR appeared to be . For this reason, it was deemed appropriate to pursue our collection of tonic heart rate data with improved pick-up and processing methodology, to provide further information regarding heart rate as an index of undifferentiated tonic arousal.

Design and experimental questions

Three different groups of 4 animals each were employed in this study. The first group contained 4 monkeys previously run in an instrumental (avoidance-punishment) conditioning procedure (Kimmel et al, Note 1) with visual discriminative stimuli. In the present study, these received the same instrumental contingencies as previously, but the visual discriminative stimuli were removed. A second group of 4 monkeys, containing animals previously run in a classical conditioning procedure, was run as a yoked control group for the instrumental subjects in the first group. That is, the animals were run in yoked pairs in such a way that the instrumental member of each pair determined with its SCRs whether shocks would be prevented during avoidance or received during punishment for both itself and its yoked control. The yoked control's responses were picked up and recorded but were not instrumental in any way. A third group of animals had never received any previous conditioning. These animals were given a series of 24 discriminative instrumental (avoidance-punishment) conditioning sessions identical to those given to the animals in the first group, i.e., without visual discriminative stimuli. In the case of the third group, however, these conditioning sessions without discriminative stimuli were the first conditioning sessions ever given to the animal. Following these 24 sessions with no discriminative stimuli, the third group was then given 24 additional conditioning sessions with the visual discriminative stimuli added. Plantar SCR and heart rate were monitored continuously in all animals and periodically sampled and recorded in the computer.

The present research was aimed at providing answers to three basic questions. The first of these questions concerned what happens when the visual discriminative stimuli used during a series of autonomic conditioning sessions are removed but the avoidance-punishment reinforcement schedule continues to be administered. It was expected that the removal of discriminative stimuli that had originally been present (and relevant) would result in a reduction in the SCR frequency differentiation that had previously been established (and, ultimately, its total loss). It was also expected that this loss of the differentiation would cause the animals to receive a greater number of shocks than previously and, in addition, would result in an increase in tonic heart rate and general arousal. In comparison to their yoked control animals, the animals receiving additional conditioning, but without the visual stimuli, were expected to show some continued tendency to differentiate between avoid- and punishment periods in terms of response frequency, to the extent to which SCR frequency is influenced by the reinforcement contingencies operating at the moment and regardless of whether stimuli that identify these contingencies are employed. The yoked controls were, of course, not expected to show any evidence of differentiation in SCR frequency between avoidance and punishment periods other than that which is a direct result of the schedule of shocks received, since these animals' SCRs were in no way influencing their environments instrumentally. But, because the SCR is reliably elicited by shock, it was thought that some difference between periods of high and low shock frequencies (such as occur in punishment and avoidance, respectively) might be found even though the shock-elicited responses themselves were automatically excluded by the computer.

Although there was no firm basis for predicting what would happen when the instrumental contingencies were administered beginning with the very first conditioning session, the expected answer to this question was that very little SCR differentiation between the avoidance and punishment periods would occur but mush more elevated heart rates would probably be seen. The latter expectation was based upon the conjecture that the lack of external stimuli by means of which to identify the avoidance and punishment periods would be more neurotigenic, more arousal-producing, than the instrumental conditioning schedule with the stimuli present.

Similar logic suggests the answer to the third question, "What will happen when discriminative stimuli are added following initial avoidance-punishment conditioning of the SCR without discriminative stimuli?" To the extent that the absence of the discriminative stimuli was an added factor in the genesis of chronic emotional arousal, as reflected in tonic heart rates, etc., the subsequent introduction of the stimuli would be expected to result both in reduction of chronic arousal and the development of (or increase in) the SCR differentiation between avoidance and punishment. Just as the omission of the discriminative stimuli may be thought of as neurotigenic, their subsequent introduction may be considered to be potentially therapeutic.

Method

Subjects

Twelve adult male Cebus albifrons monkeys served as subjects (Ss) in the experiment. Four of these animals had received 25 prior instrumental SCR conditioning sessions and two extinction sessions more than six months before the present study began. These animals constitute the Light-Omitted instrumental group. Another four animals had previously received 25 classical aversive conditioning sessions, more than six months prior to the present study. These animals served as yoked controls for the animals in the Light-Omitted instrumental group and were chosen on the basis of the degree of similarity of their rates of emission of unelicited SCR's to the four instrumental animals with which they were yoked. A third group of four animals had never received any prior training. These animals constituted the Light-Added instrumental group.

Apparatus

The animal was restrained in a specially designed plexiglass primate chair with neck, chest, and waist yokes which prevented manual contact with the skin electrodes but which permitted the animal to remain comfortable for at least one hour. The monkey's tail protruded through a hole in the back of the chair for attachment of shock electrodes. The chair also contained attachments for restraining the animal's feet. The monkey's tail and upper chest regions were shaved prior to each day's data-collection.

A bipolar electrodermal recording configuration was employed, in which the monkey's two plantar foot surfaces were series resistors in a constant-voltage circuit, with an output proportional to skin conductance (Venables &

Christie, 1974). The electrodes were of the zinc-zinc sulphate type (1.13 $cm.^2$), in teflon cups filled with saline paste. The total constant voltage across the monkey's skin was 0.5 v. DC. The output of the skin conductance circuit was amplified by instrumental operational amplifiers and digitized by a voltage-to-frequency converter. The square-wave output of the voltage-to-frequency converter was processed by a Data General Nova 2 computer, which was programmed to maintain a continuous search for unelicited SCR's utilizing time-bins of 0.33 sec. and a response criterion of two successive time-bins of 0.18 micromhos of increase in conductance per 0.33 sec. The actual response criterion, thus, was 0.36 micromhos over three successive bins. Slow drifts in basal conductance were monitored in the conductance input circuit and appropriate entries periodically teletyped into the computer. All responses that met or exceeded the criterion were counted by the computer.

The computer program also detected downward conductance changes of 0.60 micromhos or more which occurred within a time-bin of 0.33 sec., on the assumption that these probably resulted from movements which caused abrupt reductions in conductance at the skin-electrode junction. Each of these movement-produced decreases in conductance was automatically followed by 2.0 sec. of time-out from contingencies, to prevent "rebound" conductance increases from counting as instrumental responses. The parameters of both the SCR and movement artifact software were developed iteratively, combining both *a priori* and empirical considerations.

The cardiac signal was picked up by two adhesive stress-test cardiac electrodes (K & G, DME, 95-40 Pediatric Foam) in the right and left upper chest regions after examination of the signal indicated adequate placement. It was

amplified by a Grass Model 7 polygraph and fed into the coil of a relay whose contacts delivered a DC pulse to the computer coincident with each heart beat. The computer was programmed to count heart beats and record sequences of interbeat interval during predetermined periods.

Gross body movements were measured via transducer attached to the primate chair at about the animal's shoulders. The transducer included aluminum tubing 11.50 cm. long with an inside diameter of 1.91 cm. A metal disc (2.06 cm.) was suspended by fine wire (#36 Beldenamel) within the tubing. Each time the metal disc made contact with the tubing a circuit was completed and a DC pulse was delivered to the computer. Each completion of the circuit was counted as a movement by the computer.

The primate chair containing the monkey was placed inside of a sound-attenuated chamber, 86.4 cm. wide, 73.7 cm. deep, and 116.8 cm. high, so that the animal's face was oriented towards and about 36 cm. away from a primate press-panel which displayed the visual stimuli. A 15 watt house light and speaker which delivered an 80 dB continuous white masking noise were located behind the monkey. The electric shock was 3.0 mamps. in intensity and had a duration of 0.2 sec. It was administered to the animal's tail via 7 mm stainless steel electrodes. All of the equipment, including the computer and teletype, was located in a room adjacent to that which contained the sound-attenuated monkey chambers.

Procedure

All of the animals received a minimum of two weeks of handling and placement in the primate chairs prior to the beginning of the data-collecting part of the experiment. The Light-Omitted instrumental animals then were given

four booster conditioning sessions with their original contingencies (Kimmel, et al, 1977) and discriminative stimuli. The yoked control animals were run with their instrumental pair-mates during these booster sessions and, thus, were introduced to the non-contingent shocks contingent upon the responding of the instrumental subjects with which they were yoked. The visual stimuli were not presented to the yoked controls. The four animals in the Light-Added instrumental group did not receive any training with the visual discriminative stimuli initially but were directly introduced to the instrumental condition-ing regimen without lights, as described below.

Conditioning without discriminative stimuli. This part of the experiment involved all three groups of 4 animals. The first, the Light-Omitted instrumental groups, had previously received differential instrumental conditioning with visual discriminative stimuli. They were now given 24 sessions of further differantial instrumental conditioning with the visual stimuli removed. The second group of animals was run as yoked controls to these four Light-Omitted instrumental animals. These yoked controls were previously used as classical conditioning subjects. The third group, the Light-Added group, received the identical differantial conditioning schedule as was given to the Light-Omitted group. These subjects, however, had never previously received any conditioning whatsoever and were introduced to the differential instrumental conditioning schedule without visual stimuli from the outset. They were run without yoked controls.

The instrumental conditioning procedure without lights was run on a schedule of two sessions per week for a total of 24 sessions. Each session contained four avoidance and four punishment segments, administered in a random sequence with the restriction that the same type of segment could not occur more than twice in a row, except to complete the daily quota. Avoidance and punishment segments were always separated by a 30 second period of time

out from contingencies. During avoidance segments, electric shock was administered every 40 seconds if the animal did not make a criterion SCR. Criterion SCR's postponed shock for 40 seconds. During punishment segments, SCR's were followed immediately by response-contingent shock. All shocks were followed by 5 seconds of time out from contingencies to prevent shock-elicited responses from being treated as operant responses. During the first seven segments of each session, there was an initial period of 30 seconds free of contingencies and shocks, for measurement of psychophysiological data. During the eighth segment this initial period was lengthened to 90 seconds. The final 10 seconds of each segment was also shock-free. The duration of the first seven segments of each daily conditioning session varied randomly among 4.66, 4.16, and 3.16 min. The final segment of each session could be 60 seconds longer. Whether the eighth segment was a punishment or avoidance segment depended on the random sequence of avoidance and punishment segments during the first seven segments. Mean segment length was 4.30 min. Session length was about 40 min., on the average, not including the initial periods of 10 min. for electrode stabilization, or the time needed to prepare and remove the animal.

Addition of visual discriminative stimuli. This part of the experiment involved only the Light-Added group of four animals and was introduced without interruption following the last conditioning session without lights, described above. Red and green visual discriminative stimuli, presented via the primate press panel, were now added to the conditioning situation. The schedule of avoidance and punishment segments, with interpolated periods of time out from contingencies, was continued as before, with the only difference being that they were now differentiated by the visual stimuli. Time out now excluded the visual stimuli as well as the contingencies. Otherwise the schedule was the same as that which obtained during the first 24 sessions for these animals. There were 24 sessions run with the lights added.

Results

The data presented below are organized in relation to the three basic questions the present investigation sought to answer. The first of these questions, "What happens when the visual discriminative stimuli are removed but the avoidance-punishment reinforcement schedule continues to be administered?" involves a comparison of data from the 4 monkeys in the Light-Omission group of the present study with some previously collected data from the same animals. An additional approach to this question is obtained by means of comparing the performance of the 4 monkeys in the present Lights-Omitted group with their 4 yoked controls, who received the same schedule of administration of shocks with no visual stimuli present but for which these shocks were not response-contingent. The second question, "What happens when the avoidance and punishment reinforcement contingencies are administered with the visual discriminative stimuli omitted from the outset of conditioning?" involves a comparison of data collected from the 4 monkeys in the Light-Added group during their initial 24 conditioning sessions (when no lights were employed) with 4 monkeys (the Light-Omitted group) during their original 24 conditioning sessions with the visual stimuli present. The third question, "What happens when the discriminative stimuli are added to the conditioning situation after the animals have first been run in the conditioning procedure without them?" involves a comparison of the performance of the 4 animals in the Lights-Added group during their initial 24 conditioning sessions, when there were no lights present, with their subsequent 24 conditioning sessions when the lights were added.

Removal of the discriminative stimuli

The average frequency of the unelicited SCR/minute during the avoidance and punishment periods is presented in Figure 1 for the two series of conditioning sessions experienced by the Lights-Omitted animals, one series of 24 sessions during which the lights were employed and another when the lights were omitted. This within-subject contrast involves a time gap of almost one year between the two series of conditioning sessions. Two extinction sessions had been run three months after the first conditioning series and four retraining sessions with the lights were run just before the beginning of the second conditioning series. As can be seen in Figure 1, removal of the visual discriminative stimuli had the effect of reducing the differentiation, quite clearly via an increase in response frequency during punishment. Analysis of variance of the data shown in Figure 1 (n = 4) indicated that the overall avoidance-punishment difference was significant, $F\ (1, 3) = 11.05$, $p < .05$, and the interaction between the avoidance-punishment effect and the presence or absence of the lights was highly significant, $F\ (1, 3) = 24.17$, $p < .01$. Thus, removal of the discriminative stimuli reduced the extent to which the animals responded at a differential rate during the avoidance and punishment periods, as would be expected if the discrimination actually were under the control of the visual stimuli.

---------- Figure 1 about here ----------

Figure 2 presents a comparison of the avoidance-punishment difference in frequency of unelicited SCR/minute between the Lights-Omitted and Yoked Control groups, averaged in four blocks of six conditioning sessions. As can be seen

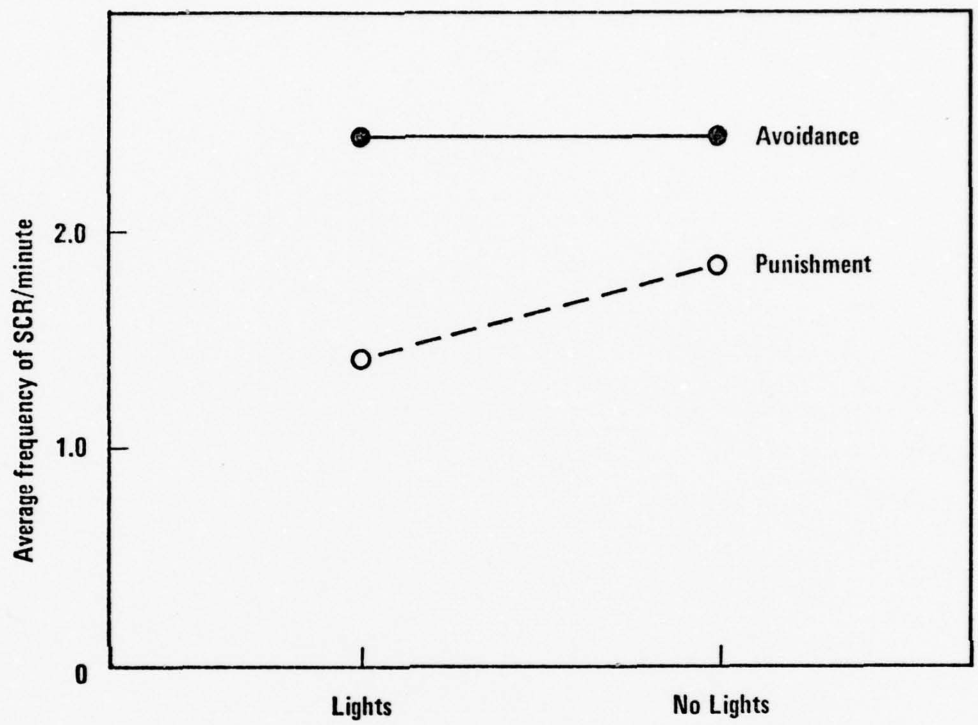

Fig. 1. Average frequency of unelicited SCR/minute of Lights-Omitted monkeys (n = 4) in avoidance and punishment conditioning with visual discriminative stimuli (Lights) and without discriminative stimuli (No Lights).

in Figure 2, there was some increase in the differentiation during the early conditioning sessions with the discriminative stimuli omitted, but this increase was present in the Yoked Control group almost to the same extent as in the response-contingent, experimental animals. Towards the end of conditioning without the discriminative stimuli, the avoidance-punishment difference reduced in the Lights-Omitted animals but appeared to stabilize in the yoked controls. Analysis of variance of these data ($n = 8$) showed that the overall difference between the avoidance and punishment periods (both groups combined) was significant, $\underline{F}$ (1, 6) = 13.16, $p < .05$, as was the overall increase in the differentiation across blocks of conditioning sessions, $\underline{F}$ (3, 18) = 6.20, $p < .01$, and across successive segments within-sessions, $\underline{F}$ (3, 18) = 5.19, $p < .01$. The 3-way interaction between the avoidance punishment difference, experimental sessions, and groups (experimental vs yoked controls) was also significant, $\underline{F}$ (5, 30) = 3.08, $p < .05$. Thus, even though there was a decline in the SCR/minute differentiation (cf. Figure 1) when the discriminative stimuli were removed, it was still sufficiently present to result in a difference between the experimental and yoked control subjects, although this difference was clearly declining in the last block of six sessions.

---------- Figure 2 about here ----------

The Lights-Omitted and yoked Control groups also differed in their patterns of overt skeletal motor activity, as picked up by the transducer attached to the primate chairs. There was a very small and statistically insignificant tendency for the animals to move more frequently during the avoidance as compared with the punishment periods. However, this difference was about five times greater in the yoked controls than in the experimental animals and

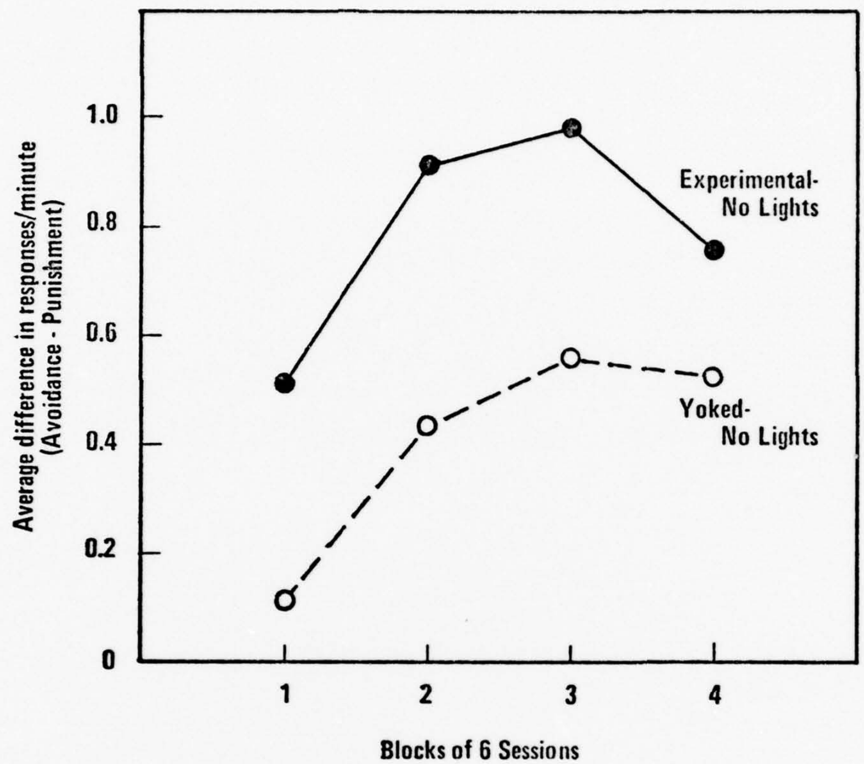

Fig. 2. Average difference in frequency of unelicited SCR/minute in avoidance and punishment in Lights-Omitted (n = 4) and Yoked Control (n = 4) animals during 4 blocks of 6 conditioning sessions.

this interaction between groups and the avoidance-punishment difference was statistically significant, F (1, 6) = 6.27, $p < .05$. Thus, the difference between the Lights-Omitted animals and their yoked controls in differential frequency of SCR/minute between the avoidance and punishment periods cannot easily be attributed to skeletal mediation, since the skeletal movement difference between avoidance and punishment was much greater in the Yoked Control group than in the Lights-Omitted group, but the SCR/minute difference was much greater in the Lights-Omitted group than in the yoked controls.

Removal of the visual discriminative stimuli in the Lights-Omitted group, after they had first received 24 conditioning sessions with the stimuli present, also influenced their tonic heart rate levels (measured during the time out periods, when no contingencies or shocks were present and, even during 24 conditioning sessions when the discriminative stimuli were being used, the lights were also omitted). However, in the case of tonic heart rate the effect was nondifferential in the sense that the time out periods are neither avoidance nor punishment periods and the effects observed did not depend upon whether avoidance or punishment immediately preceded the times out. Figure 3 shows the tonic heart rates in the Lights-Omitted group during the early and late six conditioning sessions of the conditioning series with the visual stimuli and, subsequently, without the visual discriminative stimuli, as a function of successive stimulus segments within-session. As can be seen in Figure 3, tonic heart rate tended to increase across successive time out segments within the conditioning sessions, when the lights were present, so that it was higher near the end of the daily sessions than at the beginning of these sessions. But, by the last 6 conditioning sessions without the lights, no increase at all in heart rate occurred from the beginning to the end of

these conditioning sessions, and, accordingly, the terminal tonic heart rate reached by the 4 monkeys in the Lights-Omitted groups tended to be somewhat lower than they had reached previously. The 3-way interaction between discriminative stimuli present versus absent, early versus late six conditioning sessions, and successive stimulus segments within-sessions, shown in Figure 3, was significant, $\underline{F}$ $(3, 9) = 4.44$, $p < .05$.

---------- Figure 3 about here ----------

Discriminative stimuli omitted during initial conditioning series

The Lights-Added group was first given 24 conditioning sessions without the discriminatve stimuli. Figure 4 presents the frequency of unelicited SCR/minute during the avoidance and punishemnt periods in this group,during this initial series of conditioning sessions without the visual discriminative stimuli (No Lights). Also shown in Figure 4 are SCR/minute data from the equivalent initial conditioning series for the 4 Lights-Omitted animals, at a time when they were receiving the visual stimuli (Lights). The data are averaged for four blocks of six sessions for the No Lights condition in Figure 4 but only the first and fourth blocks were available for the previously run Lights condition. As can be seen in Figure 4, the avoidance-punishment differentiation was present very early in animals conditioned with the discriminative stimuli (i.e., within the very first block of six sessions in the Lights condition) but did not attain an equivalent size in the animals conditioned without the discriminative stimuli until their very last block of sessions. Analysis of variance of these data (omitting the second and third blocks from the No Lights condition) showed that the 3-way interaction depicted in Figure 4 was significant, $\underline{F}$ $(1, 6) = 15.51$, $p < .05$ reflecting the fact that

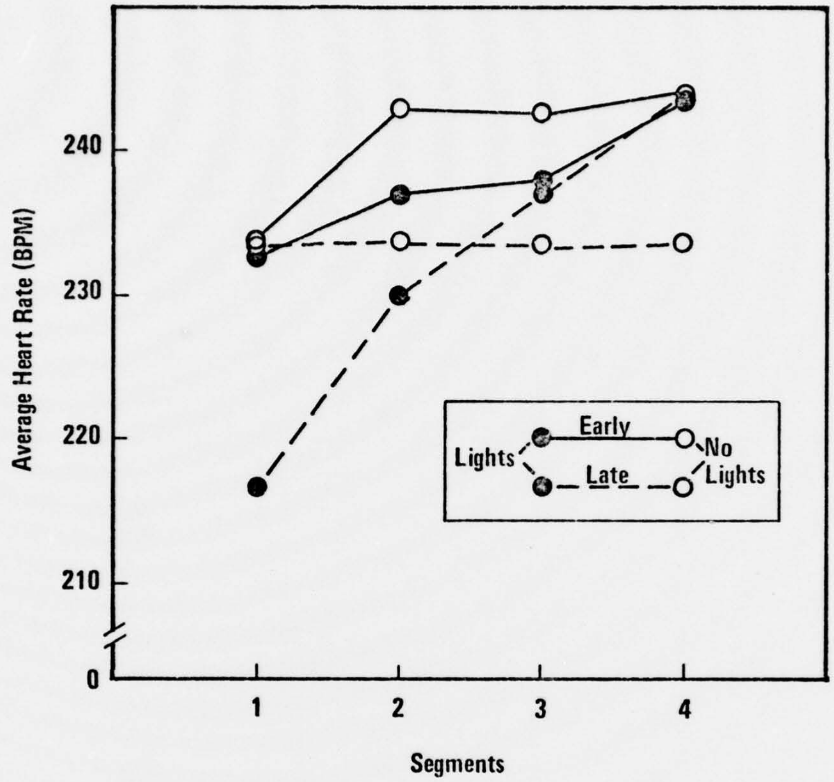

Fig. 3. Tonic heart rate (PM) of 4 Lights-Omitted monkeys during conditioning with visual discriminative stimuli (Lights) and without discriminative stimuli (No Lights), averaged within successive time out segments in the 1st block (Early) and 4th block (Late) of 6 sessions.

the avoidance-punishment effect was relatively constant throughout in the Lights condition but came into existence only in the last block of sessions in the No Lights condition. The overall difference in response frequency between the two groups was not significant. Both groups tended to increase in resonse frequency during their initial series of conditioning sessions, $\underline{F}$ (1, 6) = 10.94, $p < .05$.

---------- Figure 4 about here ----------

Despite the fact that both groups tended to increase in unelicited SCR/minute between the first and last blocks of six conditioning sessions, they did not both show an analogous increase in their response frequency measures obtained during the initial 30 sec. periods at the beginning of each avoidance and punishment segment, when the contingencies were not being implemented (when the animals are being run without the visual stimuli, of course, these contingency-free periods are indistinguishable from the preceding time out period,since there is no external event marking the beginning of a segment and the time out period is contingency-free). In the group conditioned with the lights present (with an external event associated with the contingencies and marking the "end" of the time-out) there was an increase in SCR/minute measured during these 30 sec. periods (from first to last block of session), from 2.270 to 4.114. But, in the group conditioned with no lights (with no external event associated with the contingencies and, thus, nothing to mark the "end" of time out and the "beginning" of the 30-sec. contingency-free periods), there was a reduction from the first to the last block of sessions, from 3.178 SCR/minute to 2.364 SCR/minute. This interaction between blocks of conditioning sessions and Lights present or absent was significant, $\underline{F}$ (1, 6) = 7.21, $p < .05$. Thus, the tendency towards <u>increased</u> responding

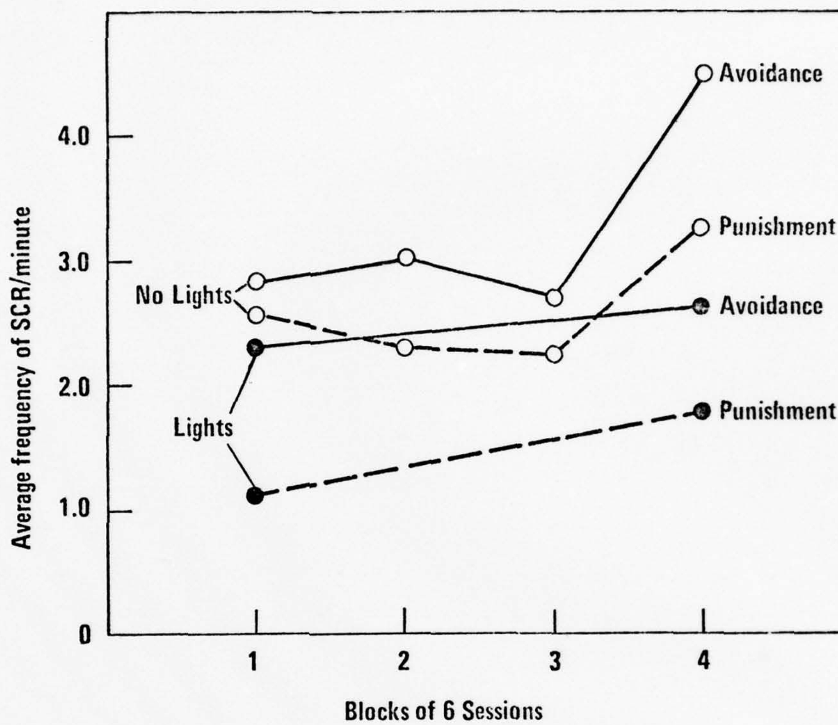

Fig. 4. Average frequency of unelicited SCR/minute during avoidance and punishment in 4 Lights-Omitted monkeys conditioned with visual discriminative stimuli (Lights - 1st and 4th blocks of 6 sessions only) and in 4 Lights-Added monkeys conditioned without discriminative stimuli (No Lights - all 4 blocks of 6 sessions).

in the No Lights condition was observable only during periods when the contingencies were in effect, as would be expected from the fact that there were no external stimuli being employed in this condition. When response frequency was measured in the absence of the contingencies (i.e., in the 30-sec. periods) it was seen to decline rather than increase during conditioning.

The 4 animals conditioned initially without the lights received a greater number of shocks during punishment than the animals conditioned first with the lights. Table 1 shows these data. The group run initially without lights received over four times as many shocks during punishment as avoidance in their first block of sessions, while the animals conditioned with the lights received only slightly more shocks in punishment than in avoidance. Although the animals run without the lights reduced in the number of shocks received during the last block of six sessions, they continued to receive a large number of shocks during punishment. Particularly noteworthy in Table 1 is the fact that the animals conditioned with the lights showed a within-session reduction in number of shocks received during punishment during the last six conditioning sessions while the animals run without the lights showed a within-session increase in number of punishment shocks received during this period. Analysis of variance of these data indicated that the two groups differed significantly overall in number of shocks received, $F\ (1, 6) = 6.34$, $p < .05$, the difference between the number of shocks received in avoidance and punishment by both groups was significant, $F\ (1, 6) = 9.57$, $p < .05$, and the avoidance punishment difference (in both groups) increased significantly from the first to the last block of conditioning sessions, $F\ (1, 6) = 10.89$, $p < .05$. The 4-way interaction shown in Table 1, between, Avoidance-Punishment, Groups (Lights), Blocks of Sessions, and Intrasession Segments, was also significant, $F\ (3, 18) = 3.75$, $p < .05$.

---------- Table 1 about here ----------

Administration of the avoidance and punishment contingencies without the visual discriminative stimuli also resulted in initially elevated tonic heart rates, as compared with initial heart rates in animals conditioned with the discriminative stimuli. Figure 5 presents these heart rate data averaged for early and late blocks of six conditioning sessions in 4 animals conditioned initially with the discriminative stimuli (Lights) and 4 animals conditioned initially without them (No Lights), as a function of successive stimulus segments within-sessions. As is indicated in Figure 5, the animals that were conditioned without the lights showed a reduction in heart rate from early to late in conditioning, but did not attain the relatively low initial heart rates shown with the stimuli in the late sessions. There was a clear tendency towards intra-session increase in heart rate in the animals conditioned with the discriminative stimuli as compared to those conditioned without them, but this appeared to be due primarily to the former animals being increasingly able to achieve lowering of heart rates between sessions and, thus, beginning each successive session with lower and lower rates. The 3-way interaction of Early-Late, Lights, and Segments, shown in Figure 5, was significant, $\underline{F}\ (3, 18) = 4.01$, $p < .05$.

---------- Figure 5 about here ----------

<u>Adding discriminative stimuli following conditioning without them</u>

The Lights-Added animals first received 24 conditioing sessions without the discriminative stimuli and, following this, the visual stimuli were introduced and a second series of 24 conditioning sessions was run. These two conditioning series were separated only by the customary intersession

Table 1. Number of shocks/minute during avoidance and punishment in monkeys conditioned initially <u>with</u> (n = 4) and initially <u>without</u> (n = 4) discriminative stimuli averaged in 1st (Early) and 4th (Late) blocks of 6 sessions, presented in successive segments within sessions.

			SEGMENTS			
			1	2	3	4
LIGHTS	Early	Av	0.79	0.92	0.83	0.67
		Pun	0.79	1.12	1.29	1.29
	Late	Av	0.54	0.58	0.58	0.54
		Pun	1.92	1.79	1.71	1.71
NO LIGHTS	Early	Av	0.88	0.92	0.75	0.83
		Pun	2.96	2.75	2.50	2.88
	Late	Av	0.46	0.58	0.46	0.46
		Pun	2.88	3.04	3.58	3.62

Av = avoidance, Pun = punishment

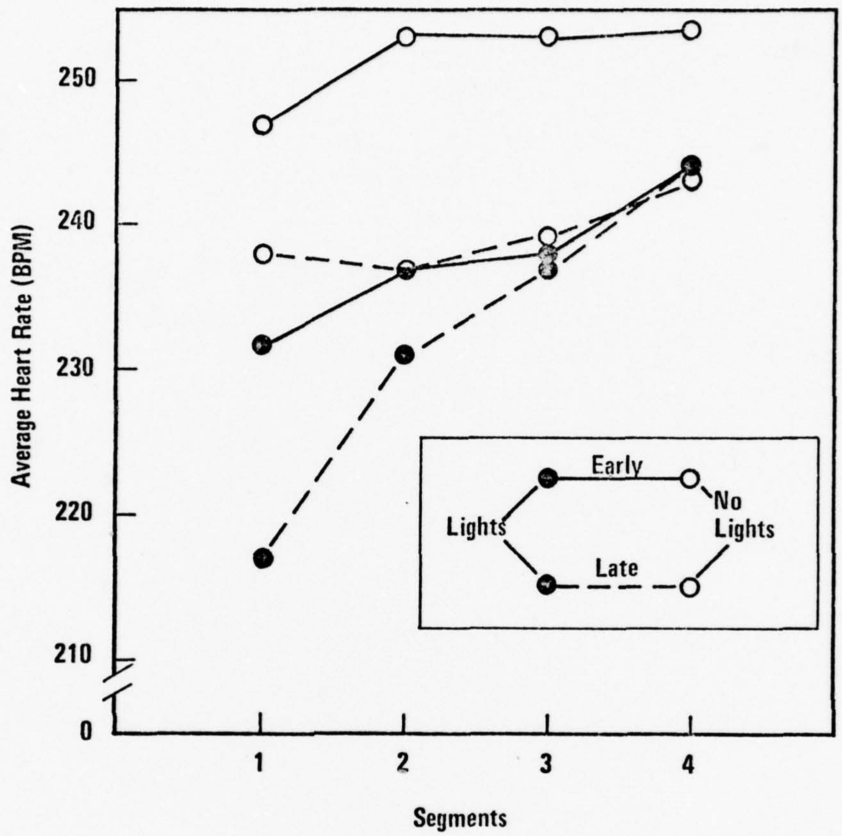

Fig. 5. Tonic heart rate (BPM) of 4 Lights-Omitted monkeys conditioned initially with discriminative stimuli (Lights) and 4 Lights-Added monkeys conditioned initially without discriminative stimuli (No Lights), averaged within successive time out segments of 1st (Early) and 4th (Late) blocks of 6 sessions.

time (i.e., the procedure of two sessions/week continued). The effect of adding the lights on the frequency of unelicited SCR/minute during the avoidance and punishment periods is shown in Figure 6, which presents these data for both series of 24 conditioning sessions, in eight successive blocks of six sessions each. The differentiation that had first come into substantial existence in the last block of conditioning without the lights was clearly maintained at high level thereafter. The tendency towards increased response frequency overall appeared to abate and response frequency declined noticeably in the last two blocks of conditioning with the lights. Analysis of variance of the data shown in Figure 6 indicated that the 3-way interaction shown in the figure was highly significant, $\underline{F}$ (3, 9) = 3.92, $p < .01$, as was the overall difference between avoidance and punishment $\underline{F}(1,3) = 29.46$, $p < .05$. The overall shift from increasing frequency of responding during the first four blocks without the lights to reduction in frequency during the last four blocks without them also was highly significant, $\underline{F}$ (3, 9) = 11.08, $p < .01$.

---------- Figure 6 about here ----------

As might be expected on the basis of shock data reported above, the adding of the discriminative stimuli also resulted in a shift in the relative frequency of shocks administered during the avoidance and punishment periods. When the lights were added there was a reduction of shock frequency during avoidance and an increase during punishment. This interaction between Lights present of absent and the Avoidance-Punishment difference was significant, $\underline{F}$ (1, 3) = 11.15, $p < .05$, as was the overall difference between avoidance and punishment, $\underline{F}$ (1, 3) = 11.65, $p < .05$.

Adding the visual discriminative stimuli following a series of 24 conditioning sessions without them also influenced tonic levels of heart rate.

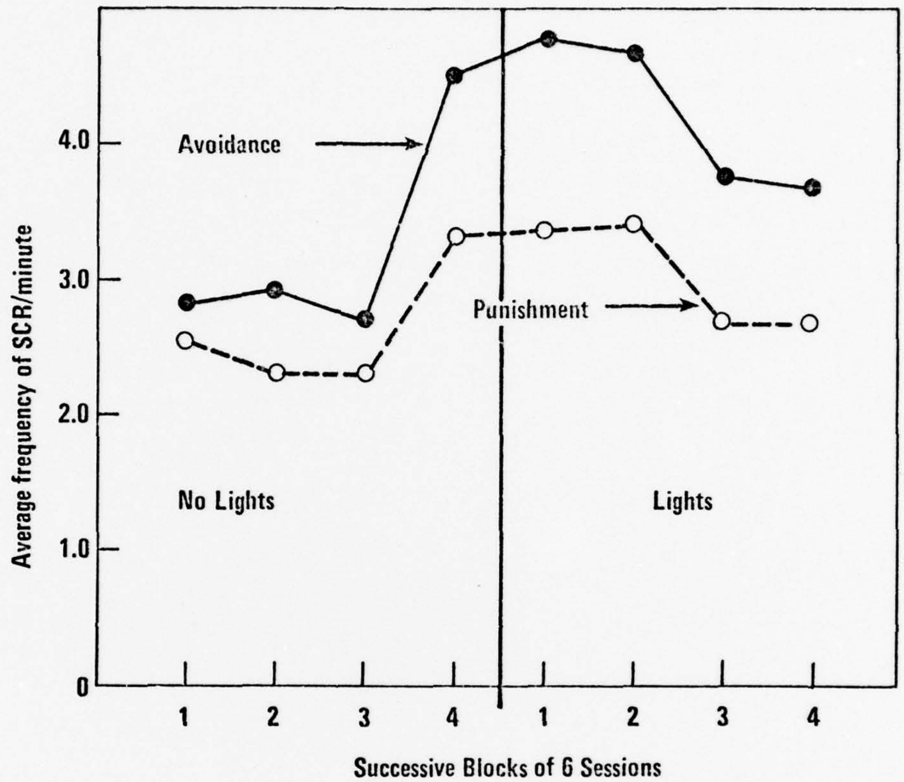

Fig. 6. Average frequency of unelicited SCR/minute during avoidance and punishment in 4 Lights-Added monkeys conditioned initially without visual discriminative stimuli (No Lights) and shifted to conditioning with discriminative stimuli (Lights), in 8 successive blocks of 6 sessions.

Figure 7 shows the tonic (time out) heart rates across successive intrasession segments, averaged in four blocks of six conditioning sessions without the lights) numbered 1,2,3, and 4 in the figure) and four blocks of six sessions with the lights added (similarly numbered). As can be seen in Figure 7, there was a turnabout in the direction of intrasession changes in heart rate which appeared to result from the addition of the lights. That is, in the left panel of Figure 7 (No lights) the course of intrasession heart rate change was upward, with an intersession tendency in the direction of reduced heart rates (from very high initial levels), while, in the right panel of Figure 7 (Lights), on the other hand, the upward intrasession course of heart rate for the first two blocks of sessions reversed itself into a downward course, especially in the last block of six sessions. The 3-way interaction depicted in Figure 7, between the presence or absence of the lights, blocks of sessions and segments within-session, was significant, $\underline{F}$ (9, 27) = 3.08, $p < .05$.

---------- Figure 7 about here ----------

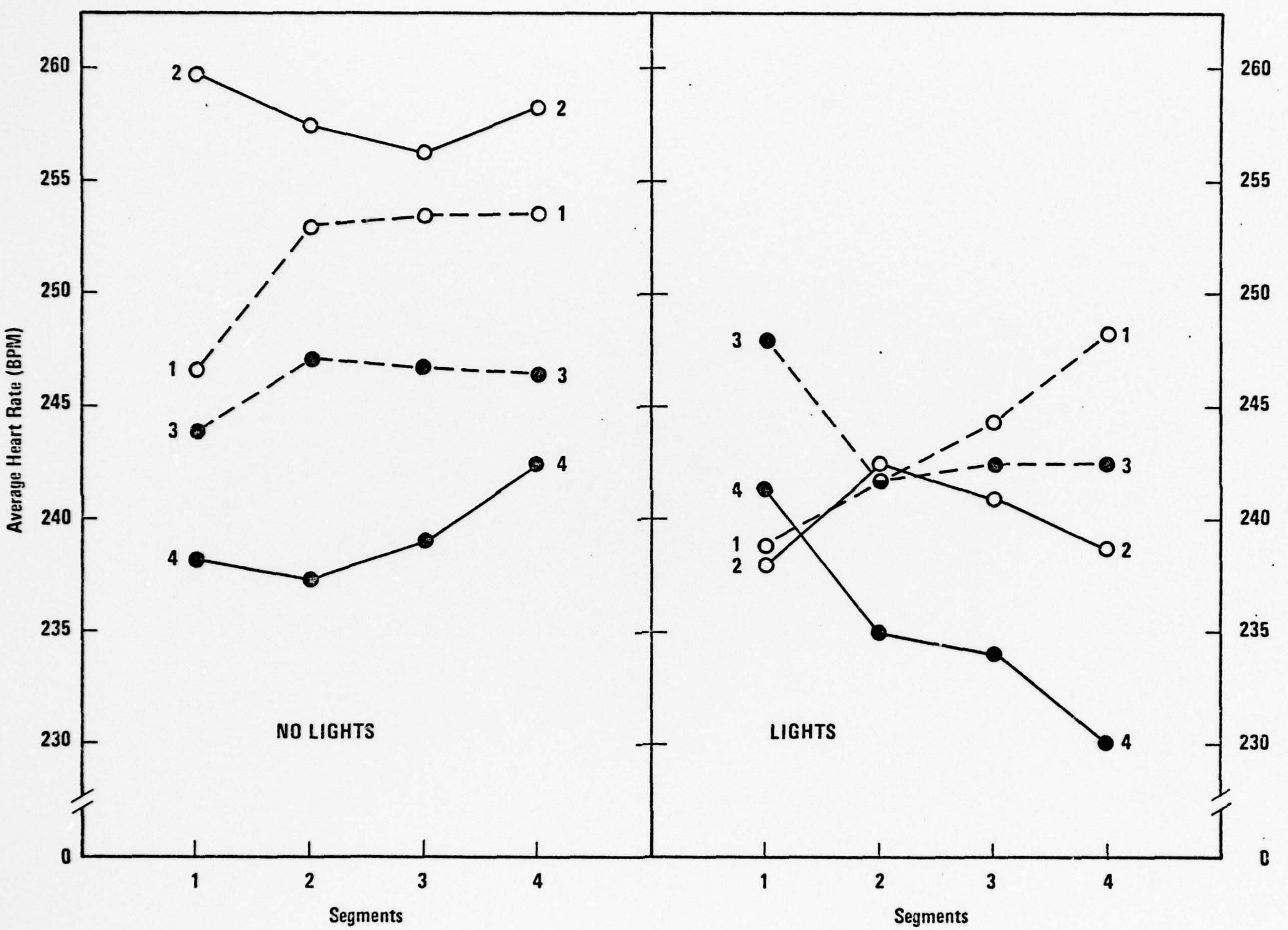

Fig. 7. Tonic heart rate (BPM) in 4 Lights-Added monkeys conditioned initially <u>without</u> discriminative stimuli (No Lights) and shifted to conditioning <u>with</u> discriminative stimuli (Lights), averaged in successive time out segments in blocks of 6 sessions (numbered in each panel of figure successively 1 - 4 within series).

Discussion

This study was designed to answer three specific questions regarding the role played by the exteroceptive discriminative stimuli in a discriminative instrumental autonomic conditioning situation. The first question concerned a situation in which animals that had previously been instrumentally conditioned with visual discriminative stimuli received further conditioning with the stimuli omitted. Here the question was simply, "What happens when the stimuli are removed after having first been present?" The second question dealt with a situation in which animals received differential instrumental conditioning without discriminative stimuli being initially associated with the different reinforcement schedules. Here the question was, "What happens when the differential reinforcement schedules are used but there are no discriminative stimuli?" The third question followed up on the second one, since the animals that had first been conditioned without the stimuli were then given further conditioning with the stimuli added. Here the question was, "What happens when discriminative stimuli are introduced following initial differential instrumental conditioning without them?"

We have previously reported at length regarding the effect of the present discriminative instrumental autonomic conditioning procedure, in which Sidman avoidance and response-contingent punishment of the unelicited SCRs are signalled by visual stimuli that differ in color (Kimmel et al, Note 1). Basically, this procedure resulted in a significantly higher frequency of SCR/minute during avoidance than during punishment. In addition, there was a large increase in tonic heart rate which did not differentiate between the avoidance and punishment segments. In the present study, when the visual stimuli were

removed, the previous differentiation of SCR frequency reduced significantly, as was shown in Figure 1. However, some differentiation clearly persisted throughout the present series of 24 conditioning sessions without the lights. Figure 2 showed that the monkeys that received the avoidance and punishment procedures with the lights omitted nevertheless showed greater avoidance-punishment differentiation in SCR/minute than was shown by a group of yoked control animals that were given the same patterns of shocks noncontingently. Because of the fact that the yoked controls showed some tendency towards an increase in the avoidance-punishment difference (Figure 2), it is highly likely that some of the avoidance-punishment difference observed in the previous study (with the stimuli present), as well as in the present study (without the stimuli), was due to the pattern of shocks generated by the reinforcement schedules, the effect of the SCR's that were elicited by these shocks, and the pattern of time out periods following shocks. However, the fact that there was a significant difference between the Lights-Omitted monkeys and their yoked controls in the extent to which they differentiated between avoidance and punishment means that a substantial part of the apparent instrumental conditioning effect was probably due to instrumental conditioning, in the usual meaning of the term, as opposed to some kind of artifact.

Omission of the lights following a series of conditioning sessions in which they were first employed also influenced the monkeys' tonic heart rates. As was shown in Figure 3, when the lights were used there was a tendency for tonic heart rate to increase from segment to segment within-sessions, especially in the last blocks of six sessions. But, when the lights were omitted this tendency changed, so that the monkeys showed no increase in heart rate within-session during the last six sessions without the lights. It appeared almost as if the lights had the effect of permitting the animals to begin each

session (in the last block of six with lights) with a reduced heart rate, which then increased during the session. Without the lights, heart rates tended to be higher at the beginning of a session, in the last block of six sessions without the lights, but not to increase within-session.

When the monkey receives the avoidance-punishment reinforcement schedule in relation to the SCR, but there are no visual discriminative stimuli present from the very first conditioning session, very little tendency towards differentiation in SCR frequency between avoidance and punishment was seen until the fourth block of six conditioning sessions. Compared to animals that have the lights present, monkeys conditioned without them obviously required many more sessions to show the differentiation. However, the absence of the lights tends to foster somewhat higher overall response frequencies, especially during the last block of six sessions, although this apparent difference between conditions was not statistically significant. This tendency towards increased responding was also seen in the first 30 seconds of the avoidance and punishment segments, when the contingencies had not yet been instituted, but only when there were discriminative stimuli to mark these periods. When there were no discriminative stimuli used, the increase in SCR frequency mentioned above was noticeable only during times when the contingencies were actually being applied. During the 30 second periods just prior to the introduction of each new segment's contingencies, the group without lights actually showed a decline in SCR/minute during conditioning, rather than an increase.

As was shown in Table 1, the difference in the development of differential responding between avoidance and punishment segments in animals conditioned with and without discriminative stimuli resulted in a related difference in the pattern of shocks received and in the way in which this changed during con-

ditioning. Early in training, the monkeys without the lights received ten times as many shocks during punishment as avoidance, while the animals with lights received shock frequencies in avoidance and punishment much closer to equality. In the last six sessions, however, the animals without lights reduced the number of shocks received during punishment but increased it somewhat in avoidance, while the animals with lights did the reverse.

Conditioning without the visual stimuli appeared to result in higher tonic heart rates (and, presumably, greater arousal) early in conditioning as was shown in Figure 5. During the last block of six sessions, these animals' heart rates had reduced but were still somewhat higher than those of the monkeys conditioned with the stimuli, especially at the beginning of experimental sessions, so that it was lower at the beginning of the next session. But the animals conditioned without the lights had elevated heart rates at the beginning of experimental sessions, suggesting that they had not been able to return to a lower heart rate between sessions. This possibility, which would be an important indication of chronic elevation of autonomic arousal, remains to be checked by means of heart rate measurements obtained between experimental sessions, perhaps via some kind of telemetered signal, since handling of the animal itself tends to cause substantial increases in heart rate.

Adding the discriminative stimuli after the monkey has first been conditioned without them has noticeable effects on SCR frequency, shock pattern and frequency, and on tonic heart rate. As is indicated in Figure 6, the avoidance-punishment differentiation was maintained steadily throughtout the 24 sessions after the lights were added. However, the overall level of SCR/minute was reduced during the last two blocks of six sessions, in both avoidance and punishment. Adding the discriminative stimuli had the effect of reducing

shock frequency during avoidance but increasing it during punishment. Perhaps most interestingly, as is shown in Figure 7, tonic heart rate tended to show a complete reversal of its intrasession pattern of change from before to after the lights were added. Where heart rates were increasing across segments within session when there were no lights, they were decreasing across segments after the lights had been added and several conditioning sessions had been run with them. Indeed, during the last block of six sessions with the lights, the monkeys' heart rates reduced from over 240 bpm in the initial segments to a about 230 bpm in the last segments. Thus, it may be that one of the consequences of providing discriminative stimuli that permit the animal to respond differentially between avoidance and punishment (with the SCR) is that tonic arousal may be better controlled (maintained at a lower level or reduced within session) both between and within sessions. This, of course, is the analogue of therapeutic "binding" of anxiety that is presumably achieved in the treatment or in the natural development of phobic and other stimulus-controlled emotional situations.

Of course, speculations regarding either the neurotigenic, arousal-producing effects of receiving the avoidance and punishment contingencies without exteroceptive stimuli to identify when they are being applied, or the therapeutic effects of adding the stimuli after they have initially not been present, are limited first by the unevenness of some of the results of the present and previous studies (Kimmel et al, Note 1). Although it is true that responses mediated by the autonomic nervous system are usually more error-ridden than are skeletal responses such as lever or panel pressing, nevertheless the present pattern of results is not difinitive enough to justify firm conclusions without replication and confirmation. The need for replication also stems from the fact that the present yoked control subjects had been used in a prior study of classical conditioning and, thus, were not "pure"

controls. Furthermore, it would be better to have had the same time period separating the training with the discriminative stimuli from subsequent training with the stimuli omitted as the period that separated training without the stimuli from subsequent training with them added, which was not true in the present study and its predecessor. Thus, what is needed is a systematic replication of both directions of stimulus change, with the same time parameters and with appropriate control animals.

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Reference Note

Kimmel, H. D., Brennan, A. F., McLeod, D. C., Raich, M. S., and Schonfeld, L. I., Instrumental electrodermal conditioning in the monkey (_Cebus albifrons_): Acquisition and long-term retention Manuscript submitted to _Journal of Experimental Psychology: Animal Behavior Processes_, 1978.

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Figure Captions

Figure 1. Average frequency of unelicited SCR/minute of Lights-Omitted monkeys (n = 4) in avoidance and punishment conditioning with visual discriminative stimuli (Lights) and without discriminative stimuli (No Lights).

Figure 2. Average difference in frequency of unelicited SCR/minute in avoidance and punishment in Lights-Omitted (n = 4) and Yoked Control (n = 4) animals during 4 blocks of 6 conditioning sessions.

Figure 3. Tonic heart rate (BPM) of 4 Lights-Omitted monkeys during conditioning with visual discriminative stimlui (Lights) and without discriminative stimuli (No Lights), averaged within successive time out segments in the 1st block (Early) and 4th block (Late) of 6 sessions.

Figure 4. Average frequency of unelicited SCR/minute during avoidance and punishment in 4 Lights-Omitted monkeys conditioned with visual discriminative stimuli (Lights - 1st and 4th blocks of 6 sessions only) and in 4 Lights-Added monkeys conditioned without discriminative stimuli (No Lights - all 4 blocks of 6 sessions).

Figure 5. Tonic heart rate (BPM) of 4 Lights-Omitted monkeys conditioned initially with discriminative (Lights) and 4 Lights-Added monkeys conditioned initially without discriminative stimuli (No Lights), averaged within successive time out segments of 1st (Early) and 4th (Late) blocks of 6 sessions.

Figure 6. Average frequency of unelicited SCR/minute during avoidance and punishment in 4 Lights-Added monkeys conditioned initially without visual discriminative stimuli (No Lights) and shifted to conditioning with discriminative stimuli (Lights), in 8 successive blocks of 6 sessions.

Figure 7. Tonic heart rate (BPM) in 4 Lights-Added monkeys conditioned initially without discriminative stimuli (No Lights) and shifted to conditioning with discriminative stimuli (Lights), averaged in successive time out segments in blocks of 6 sessions (numbered in each panel of figure successively 1 - 4 within series).

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12 monkeys received instrumental, autonomic conditioning (SCR) without discriminative stimuli. 4 monkeys were yoked controls and 4 had stimuli added subsequently. Differentiation was stronger with stimuli but arousal was greater without. Adding stimuli has therapeutic effect on arousal.